SITY OF IDAHO,
) RANGE EXPERIMENT STATION
AND
UNITED STATES DEPARTMENT OF THE INTERIOR,
BUREAU OF LAND MANAGEMENT

Pellet Reseeding Trials on Southern Idaho Range Lands

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Special Research Report — Project 16 — January 1, 1951

The University portion of this cooperative project was financed under a grant by the Special Research Fund.

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by

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During the past few years, various pelletizing treatments of seeds have been devised for the purpose of securing better distribution or greater germination and seedling survival. In the case of certain small-seeded row crops, pelletizing provides seed units suitable for spaced planting. The resulting benefits, in reduced amounts of seed required and in lessened labor needed for thinning have caused the method to become widely adopted by growers of garden and truck crops.

Pelletized seed has not come into general use for range and forest reseeding, but has been the subject of numerous trials by government agencies and private corporations. These trials have been given considerable publicity, much of it over-optomistic as to the possibilities of this spectacular new method.

The present report deals with tests made by the University of Idaho and the Bureau of Land Management during the past three years. The results of large-scale seedings near Gooding, Idaho, and of many subsequent small-scale field and laboratory trials are included.

The Case for Pellet Seeding

The case for pellet seeding of range lands derives from the limitations of other seeding methods. Limitations of cultural methods such as drilling, discing, and railing are well known to those who have used them, and may be readily visualized by all familiar with the rough topography and stony nature of much of the western range. Not only do the physical limitations of equipment operation prohibit use of these cultural methods on a large portion of our range lands, but costs tend to limit their application even on lands of good productive capacity.

Aerial broadcasting of naked seed by-passes many of these operational limitations. In addition, it makes possible the seeding of large areas during brief periods of most favorable conditions, as immediately after burning or just prior to seasonal growing peaks.

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A further advantage on highly erosive soils lies in the avoidance of surface soil disturbance.

Pelletized seed retains the above advantages of the aerial broadcast method, and adds to them by permitting seeding under wind conditions which often prohibit sowing of light naked seed. The siginificance of the pelletizing method, however, lies primarily in its promise of overcoming the chief limitation of naked seed by providing a substitute for soil cover.

Pelletized Seed Developments to Date

The first commercial application of pelletized seed, in this country at least, appears to have been made by Dr. Phelps Vogelsang and associates. In 1943 this group, organized as Processed Seeds Inc., used pelletizing as a means of planting segmented sugar beet seed (Anon. '46). Pelletized seed is now being used extensively for row crops in the Lake States and Pacific Coast regions.

The value of pelletized seed for forest and range plantings has not been established, but numerous trials are in progress (Rudolf '49). Experimental seedings of timber lands by this method have been made in South Carolina, Florida, the Pacific Northwest and Ontario, Canada, to mention only a few of the major tests. Comparable interest has been shown in the field of range reseeding. The first large-scale range reseeding test with pelletized seed was begun on the Papago Indian Reservation, Arizona, in April, 1946, by the Bureau of Indian Affairs (Wagner and Kinkor '49). Since that time, seedings have been made by several Federal agencies in Arizona, Idaho, Nevada, New Mexico, Utah and Wyoming.

Two principal types of seed pellet have been produced and used to date. These differ fundamentally with respect to the mode of manufacture, and often in the materials of which the pellets are made. For lack of any standard nomenclature, these may be referred to as the "coated" and "compression" types. Coated type pellets have been produced by Processed Seeds Inc., Midland, Michigan, and by the Filtrol Corporation, Los Angeles, California. Compression type pellets have been made chiefly by the International Seed Pellet Co., Phoenix, Arizona.

The coated type of pellet is formed by covering individual seeds with one or more layers of a coating substance. After the pellets have been built up to the desired size, they are dried and screened to obtain uniformity. The coating material usually consists of finely divided mineral substances such as feldspar, fly ash, clay or montmorillonite. In the Vogelsang process methyl cellulose is used as an adhesive, while in the Filtrol pellets the montmorillonite employed supplies its own adhesive qualities. The coated types of pellets are manufactured at permanent processing plants, with subsequent shipment to the seeding sites.

The compression type of pellet is formed by pressing together a mass of moistened soil or other material containing one or more

seeds. The first commercial method in this field, and the one used most commonly in range trials to date, is that developed by Dr. L. S. Adams of the International Seed Pellet Company. In this method, a mixture of earth and seed is compressed between rotating gears to form a hard, spherical pellet containing a variable number of seeds. The processing is done at or near the reseeding site, using local earth, preferably high in clay content. Recently the Filtrol Corporation has produced earthen pellets by an extrusion process which forms a pellet having much the same characteristics as the Adams type. (Fig 1.)

In both the coated and compression types, plant hormones, fungicides, etc., can be and frequently are added.

Fig. 1. Types of seed pellets: Top left—Adams type; right—Filtrol compression type; bottom left—Vogelsang coated pellets; right—coated type made in Range Management laboratory, University of Idaho.

The Need For Further Study

The current status of range reseeding is such as to justify a continuous search for new or improved methods. To date, aerial broadcasting of naked seed has proved successful only for a few favorable site conditions such as aspen ranges of the intermountain region (Plummer and Stewart '44), burned-over timberlands

in Montana (Friedrich, '47), and loose friable soils under sage-grass cover in Wyoming (Killough, '50).

Airplane broadcasting of pelletized seed is the most recent development along this line. Despite considerable activity during the past five years only a limited amount of information is available regarding the possible value of this method of forest and range reseeding. Rudolph ('49) in summarizing the results of several studies concluded that no highly promising leads have been developed to date and that further exploratory studies are needed rather than large-scale seedings. The authors endorse this view, particularly in the field of range reseeding, where most of the trials to date have been on a large scale.

A serious lack of basic information is reflected in the current literature on range pellet reseeding, much of which consists of non-technical and often uncritical magazine and newspaper articles. Only recently have reports appeared which present the results of actual investigations (Allen, '48; Tisdale, '48; Stevenson, '49; Wagner and Kinkor, '49; Rudolf, '49; and Bleak and Phillips, '50).

Cooperative Arrangement for Study of Pelletized Seeding on Idaho Ranges

In the late fall and early winter of 1947-48, two large-scale range pellet seedings were made by the Bureau of Land Management near Gooding, Idaho. Desiring to obtain the maximum information available from these tests, officials of the Bureau arranged with the University of Idaho for a cooperative study of the use of pelletized seed for range reseeding. The University part of the program is set up as a special research project involving staff members of the School of Forestry and the College of Agriculture. The present report is the first detailed coverage of the work being done in this cooperative study.

Pellet Seeding Trials of 1947-48

Using funds specifically designated by Congress for the purpose, the Bureau of Land Management in 1947 carried out trial pellet seedings in south central Idaho.

Location

Officially designated as the Thorn Creek Aerial Reseeding, this project covers some 20,942 acres lying on and marginal to two 1947 range burns about three miles apart on the Thorn Creek drainage in Wood River Grazing District, a short distance north of Gooding. The actual burned area amounts to 16,400 acres. The two burned areas represent distinct climatic and soil conditions so are separately described.

Topography

The Thorn Creek burn covers, for the most part, lands at elevations of 5,000 to 6,000 feet, near the eastern extremity of the

Bennet Hills. Sharp breaks in elevation several hundred feet in extent occur at both the north and south ends of the burn. The intervening topography is rolling to hilly.

The Rattlesnake Butte burn lies along the slope between the Bennet Hills and the Snake River Plain. The elevation ranges from 4,000 to 4,600 feet, with a fairly uniform slope to the south.

Soils

Parent materials on the Thorn Creek area are rhyolitic in nature, with frequent rock outcroppings at all levels. The derived soils have a considerable content of sharp quartz particles even in the alluvial deposits of depressions. The shallow A horizon is dark gray brown in color, of loam texture, with an organic matter content of approximately five per cent. The B horizon is more compact and finer in texture. There is no evidence of a calcareous "hardpan." Erosion has been active on the area, particularly following fires occuring about 1925, and again in 1947. In places the topsoil has been completely removed, forming an erosion pavement (Fig. 2.). Over much of the site the top inch or more of soil has become loose following the 1947 burn, affording an unstable surface for seeding.

The soils of the Rattlesnake Butte area are formed from older

Fig. 2. Example of erosion due to repeated fires on Thorn Creek pellet reseeding area. Photo taken October 1947.

basalt flows, together with loessial materials common to this portion of the Snake River Plain. Soil development is superficial and uneven, with frequent large beds of boulders on which there is little or no soil. The whole area contains numerous surface rock fragments. The top soil is light gray in color, of silt loam texture, with an organic matter content of only 1 to 1.5 per cent. The lower layer of the shallow profile is compact and higher in clay content. Present soil conditions indicate that much of the top soil has been lost by erosion following repeated cheatgrass fires.

Climate

Climate over the Thorn Creek aerial reseeding areas is, in general, typical of the Snake River Plain, being dry and hot in summer, relatively cold in winter, dominantly sunny, with moisture limitations dictating a semi-desert plant cover. A typical station for the lower altitudes is Gooding, where the mean annual precipitation is 9.8 inches and the mean temperatures are 24 degrees Fahrenheit in January, 72 degrees in July.

Precipitation on the Rattlesnake Butte area is about the same as at Gooding, but averages 12-16 inches annually on the higher parts of the Thorn Creek burn. Virtually all precipitation on the Rattlesnake Butte site falls during the period October-April. Only late March, April and May normally provide conditions favorable to plant growth. On the higher Thorn Creek area, rains continue through May, with occasional beneficial storms in June. Most of the added moisture on the higher site, however, is due to heavier and more frequent winter storms.

The whole project area is subject to considerable air movement. Frequent, strong winds of several hours to several days duration cause heavy evaporation during the growing season.

Vegetation

All the project lies in the big sagebrush-bunchgrass type. Previous fires had eliminated sagebrush (**Artemisia tridentata**) from most of the Rattlesnake Butte area before the 1947 burn. Of the native grasses once abundant in the area, including blue-bunch wheatgrass (**Agropyron spicatum**), needle-and-thread (**Stipa comata**) and squirrel tail (**Sitanion hystrix**), only little bluegrass (**Poa secunda**) remains in sufficient amount to be an appreciable factor either as forage or as a soil binder. Cheatgrass (**Bromus tectorum**) now dominates the site, interspersed with smaller quantities of sunflower (**Helianthus annuus**) and other annual weeds (Fig. 3.).

The Thorn Creek site was occupied by big sagebrush with a sprinkling of bitter brush (**Purshia tridentata**), chokecherry (**Prunus demissa**), horsebrush (**Tetradymia canescens**) and rabbit brush (**Chrysothamnus spp.**). The herbaceous cover was dominated by little bluegrass, cheatgrass, lupine (**Lupinus sp.**) and various annual forbs. A thin stand of bluebunch wheatgrass and giant wildrye (**Elymus condensatus**) occurred on portions of the area.

The general condition of forage on both burned areas previous

to the 1947 fire was poor. The grazing capacity was between 7.5 and 15 acres per animal-unit-month, as compared to the rate of 2½ to 5 acres per A.U.M. for ranges of similar potential in good condition.

Fig. 3. Typical portion of the Rattlesnake Butte pellet seeding site, showing dominance of cheatgrass. Note stoney, untillable nature of the soil.

Total survival and regeneration of all plant cover on the Thorn Creek area did not exceed .05 density in 1948, and did not provide serious competition to reseeded plants. On the Rattlesnake Butte site the situation was much less favorable. Regeneration of cheatgrass dominated the area in 1948 and this, combined with the poor site quality, rendered establishment of reseeded perennials extremely difficult.

Preparation of Seed Pellets

The pellets used in this trial were produced by the International Seed Pellet Co., who set up a pelletizing plant near the seeding area. The pellets were made of local earth into which the seed had been incorporated. Mechanical analysis of this soil showed a composition of 50% clay, 26% silt and 24% sand. Quarter-inch pellets were used for sweetcolver seed and ⅜-inch pellets for crested wheatgrass seed. A small amount of phosphate fertilizer

was included. The pellets were formed by compression of the mixed materials between the perimeters of four wheels rotating past a common point of contact. The materials were carried to that point in quarter-spherical cups set in the perimeters of the wheels.

The pressure exerted on the materials in this process is not known. The hardest of the ⅜-inch pellets, made when the pellet wheels were new and tightly fitted, had a calculated density of 136 pounds per cubic foot of compressed material. The normal density for uncompressed clays is about 100 pounds per cubic foot. The hardest of the ¼-inch pellets had a calculated density of 162 pounds per cubic foot.

Pellets made by unworn equipment had a hardness suggestive of ripe dry peas or beans. As the pellet wheels wore, softer pellets were produced. Wheel wear was so rapid that after only two days of operation the pellets produced were soft enough to disintegrate when rolled firmly between thumb and fingers. This rapid rate of wear appeared due in large part to the presence of small sharp rock particles in the soil used for pelletizing. The majority of the pellets produced were made with worn equipment, and were corrspondingly soft.

The theoretical weight ratio of pellet material to seed in this process was 20 to 1. In actual practice the ratio was about 33 to 1, and at times ran as high as 40 to 1.

Seeding Plan and Procedure

The seeding plan provided for seeding 1.5 pounds of standard crested wheatgrass (**Agropyron cristatum**) and 0.5 pound of yellow sweetclover (**Melilotus officinalis**) per acre. These seeds were to be pelletized separately, with the crested wheatgrass in ⅜-inch pellets and the sweetclover in ¼-inch pellets. The pellets were to be distributed in a pattern of one per square foot of seeding surface. The above rates provided 10 crested wheatgrass seeds per ⅜-inch pellet and 5 sweetclover seeds per ¼-inch pellet. These seeding rates required a total weight of 68.4 pounds of pellets per acre at the densities noted above, or a ratio of roughly 1 pound of seed to 33 pounds of other ingredients. Near the center of the Thorn Creek burn two adjacent strips ½-mile wide by 2½ miles long were double and triple seeded, respectively, for comparisons on rate of seeding.

Trial flights showed that elevations of 300 to 500 feet produced pellet strips roughly 120 to 160 feet wide on the ground. Since the pellet scatter patterns, regardless of flight elevation and strip width, tended to be heaviest in the middle of the strip and lighter toward the edges, double coverage was provided by making flight strip step-overs only half the width of the ground pattern.

Flight operations were oriented to ground crew members carrying 5-by-5-foot yellow flags, who spaced the necessary step-overs by pacing or by measuring with a length of light rope. Although

lines of movement of these flagmen were plainly staked, some difficulty was found in keeping step-overs uniform. The necessity for flagmen to avoid low points and other places not readily visible from a low-flying plane often prevented these men from following their staked lines. The offsets made to reach readily visible points often were several times as great as the step-over distance and doubtless resulted in inaccurate lines in some cases.

Flights made on compass course along 2½-mile strips with only the initial point marked by a flagman proved unreliable. One check showed skips in coverage of as much as three flight strip widths at the opposite end of the strip, resulting in unseeded areas of 70 to 100 acres. Even with a flagman at each end of the flight strip the pilot easily got off course unless he could see the second flagman immediately after he passed over the first one. It was found that for accuracy of flight a flagman must be in sight ahead along the flight line at all times.

Scatter patterns, pellet density and over-all coverage were checked by a variety of observations. Direct ground recovery counts were made on a group of 25 rectangular plots aggregating 1,561 square feet. Similar counts were made on 3 linear plots 100 feet by 1 foot in size, located at right angles to the distributing plane's line of flight. On other plots white muslin sheets marked off in 1-foot squares were laid down in advance of sowing operations, and counts made after seeding.

Results of all the counts are summarized by groups in Table 1. The data show pellet densities varying from zero to 1.58 pellets per square foot, with a weighted average of 0.39 per square foot.

Table 1. — Summary of Pellet Counts on Thorn Creek and Rattlesnake Burns, November, 1947 to January, 1948.

Sample Group	Number of Samples	Pellet Counts 3/8"	1/4"	Frag.	Whole Pellet* Equiv.	Sample Area Sq. Ft.	Pellets per Sq. Ft.
Rectangular ground plots	25	298	211	171	551.75	1,561	.35
Linear ground plots	3	75	35	7	111.75	300	.37
10' x 10' counting sheet plots (Thorn Creek Burn)	11	158	132	15	293.75	1,100	.27
10' x 10' counting sheet plots (Rattlesnake Burn)	14	319	295	325	695.25	1,400	.50
5' x 5' counting sheet plots (Rattlesnake Burn)	13	91	36	102	152.50	325	.47
Totals	66	941	719	620	1,805.00	4,696	—
Averages	—	14.26	10.89	9.29	27.35	71	.39

* Four fragments equal one whole pellet.

Time and Conditions of Seeding

This seeding was planned for September, 1947, but due to delays in pelletizing it did not get under way until October 28. Further pellet production difficulties delayed completition until January 16, 1948. All sowing was too late for fall germination and much of it was done on snow. The planes often operated under

conditions of poor visibility caused by rain, fog, or low clouds, which added to the difficulty of accurate flying.

Pellets were observed to disintegrate quickly when exposed to rain or wet snow, and all are presumed to have disintegrated before spring growing conditions arrived.

Operational Difficulties

Many difficulties were encountered, some of which were incident to the terrain flown and the weather. Several of these difficulties were such as would apply equally to any reseeding method, while others could have been avoided by better timing of the work. Only those apparently inherent in the pelletizing method used will be discussed.

First was the extremely rapid wear of the pellet-forming wheels. Equipment which in other locations, according to the contractor's statement, had given 400 hours or more of satisfactory service, here gave as little as 20 to 30 hours. This was less than the time required by the contractor's supplier to manufacture the parts, so that much time was lost waiting for replacements. The contractor apparently did not consider it practical to secure better soil at a greater distance from the seeding site.

The second difficulty stemmed directly from the first, in that after the short period mentioned, that pellet wheels ceased to turn out clean-cut, hard pellets. As the wheels wore, pellet quality deteriorated to the point where half or more of the processed material passed through the equipment either totally unpelletized or so loosely incorporated that it disingrated in screening and other necessary handling. The loosely-pressed pellets became progressively more oversize, resulting in placing too many seeds in each pellet and too few pellets on the seeding area.

The third difficulty was that seed breakage increased in the reprocessing necessitated by wheel wear. A substantial amount of seed breakage appears to be inherent in the pelletizing process used, since seed occurs throughout the pellet material mixture, and a proportionate amount of it protrudes from the surface of the pellet. Data on the amount of damage are presented in a subsequent section of this report.

Results of the Seeding

Seedling counts on a total of 55 temporary plots each 5 feet square were recorded in May, 1948. These plots were located on relatively choice, open sites, free of rocks and shrubs, in order to simplify observations. A record of vegetation other than the seeded species was made as a basis for judging both present conditions affecting germination and the competitive vegetation which would affect the survival of the seeded species (Fig. 4.). The results of these observations are presented in Table 2. Large numbers of annual forb and grass seedlings were found on most plots. These popula-

Table 2 — Numbers of Crested Wheatgrass, Sweetclover and Other Plants Observed in May, 1948 Following Pellet Seedings of October, 1947, to January, 1948. (Results for 40 plots each 5 x 5 feet)

Plant Species or Class	Rattlesnake Butte Plots			Thorn Creek Plots		
	10 Plots Traverse No. 1	10 Plots Traverse No. 2	Averages Square foot	10 Plots Traverse No. 3	10 Plots Traverse No. 4	Averages Square foot
	250 sq. ft.	250 sq. ft.		250 sq. ft.	250 sq. ft.	
Annual forbs	1,641	1,609	6.5	1,965	1,229	6.4
Perennial forbs	43	453	1.0	450	515	1.9
Perennial shrubs	—	—	—	126	64	.4
Native grass crowns	46	2	0.1	142	206	.7
Native grass seedlings	1	—	0.002	—	10	.02
Cheatgrass	1,373	4,096	10.9	55	30	.17
Crested wheatgrass seedlings	—	—	—	23	3	.05
Sweetclover seedlings	1	3	0.008	3	—	.006
Total individual plants	3,105	6,163	—	2,764	2,057	—
Total plants per sq. ft.	12.4	24.7	18.5	11.0	8.2	9.6
Ungerminated crested wheatgrass seeds	7	7	.03	116	85	.4
Ungerminated sweetclover seeds	—	2	.004	—	3	.006

tions were considered to indicate favorable growing conditions to which the seeded species might be expected to respond also.

Numbers of crested wheatgrass and sweetclover seedlings were too small to constitute even a thin stand. No recognizable pellet remnants were found on sites capable of supporting forage plant growth. All the seedlings found were from isolated seeds rather than seed clusters. In each case the generating seed was observed to lie ¼ to ½ inch below the soil surface. The covering of the seed in each instance was accomplished by natural soil movement, as the pellets themselves did not penetrate into the soil surface.

Fig. 4. Typical portion of Thorn Creek Pellet Reseeding site photographed one year after being burned. Note sparse cover and dominance of weedy herbs. Unburned sagebrush stand in the background.

Seedling counts made on seventy-five 2 x 50 foot sample plots in June, 1948 showed no relationship between seedling stand and rate of seeding. Twenty-five plots each were taken in the single, double and triple seeded areas. The plots were 10 chains apart on lines running at right angles to the line of flight of the seeding planes in order to avoid sampling along possible gaps in the seeding strips. These counts disclosed totals of 2 crested wheatgrass and 22 sweetclover seedlings on the twenty-five single-seeded plots,

1 crested wheat and 10 sweetclover on the twenty-five double-seeded plots, and 1 crested wheat and 14 sweetclover on the twenty-five triple-seeded plots.

A random transect of ten 100-square-foot plots taken in November, 1950, at approximate half-mile intervals at right angles to lines of seeding plane flight gave a total of 7 crested wheatgrass plants. Five of these plants were on one plot. All but one plot of this series fell in the single-seeded area. The remaining plot fell in the triple-seeded area, but had no seedlings on it. No sweetclover plants were found in this transect.

With so sparse a stand of seedlings the above samples were not considered sufficient to establish a true relationship between results from the different seeding rates, but the data clearly show the inadequacy of the stand for reseeding purposes.

Permanent Sample Plots

During June 1948 several permanent sample plots were established in order to follow the results of the pellet seeding in greater detail. Due to the extremely sparse nature of the stand secured generally over the seeded area, it was necessary to select favored spots where the seedling populations were above average. Most of these spots were found to be on relatively level ground, close to the foot of slopes. Germination on sites of this nature may have been aided by soil washing from the slopes and covering some of the seed.

At each of 5 sites five permanent sample plots 2 by 10 feet in size were established. Counts were made of all seeded species, all grasses and the principal perennial forbs and shrubs. The plots were studied again in the summers of 1949 and 1950. The results obtained are summarized in Table 3.

Table 3 — Numbers of seeded and principal native perennial plants on 25 permanent sample plots, Thorn Creek pellet reseeding site, 1948-1950.

Plant Species	Total Numbers of Plants			Av. Number of Plants per Sq. Ft. 1950
	1948	1949	1950	
Crested Wheatgrass	27	60	51	0.10
Yellow Sweetclover	167	104	—	—
Sandberg Bluegrass	191	121	134	0.27
Bluebunch Wheatgrass	40	46	48	0.10
Other perennial grasses	45	57	65	0.13
Lupine	344	635	1,158	2.32
Big Sagebrush*	130	125	119	0.24
Horsebrush	?	23	24	0.05

* Seedlings only.

The marked increase in numbers of crested wheatgrass seedlings shown in the 1949 counts reflects additional germination which followed rains in the fall of 1948. The subsequent decline is thought

due to close spring grazing combined with poor rooting of many seedlings which appeared to have sprouted at the surface. Of 20 such poorly attached plants marked at one site in June 1949, not one was alive a year later. The number of crested wheatgrass plants alive on these select plots in 1950 represents about ten per cent of a satisfactory stand.

Sweetclover, which far outnumbered the crested wheatgrass in 1948, was grazed closely in both 1948 and 1949, hence there was no chance for natural reseeding and no stand in 1950. Mice, ground squirrels and rabbits appeared especially fond of these plants and probably were more important than livestock in keeping them eaten down.

Bluebunch wheatgrass, Columbia needlegrass, Idaho fescue and other perennial grasses suffered some fire damage but recovered considerably in subsequent years. The principal cover on the sample plots was provided by a species of lupine of low palatability which was clearly dominant by 1950. Sagebrush seedlings appeared in fair number in 1948, and most of them were well established by 1950. Horsebrush regenerated from the roots of the burned plants, and while not observed in June 1948, produced many vigorous shoots in the two years following.

Total plant cover was low in 1948 and 1949, and the vigor of native perennials was poor in 1948. The poor stand of crested wheatgrass apparently could not be attributed to excessive plant competition.

Due to the almost complete lack of seeded plants on the Rattlesnake Butte reseeded site, no permanent plots were established there.

Laboratory and Greenhouse Studies

Tests conducted at the University of Idaho, beginning in March 1948 have included studies of the composition and seed content of various lots and types of pellets, together with germination tests.

The materials studied include pellets made by the Adams process in Arizona, Idaho, Nevada, Utah, and Wyoming as well as samples of coated pellets prepared by Processed Seeds, Inc. While most of the pellets contained crested wheatgrass, some were obtained with other grasses or sweetclover.

Pellet Analyses

The difficulties encountered in making seed pellets for the seedings in southern Idaho suggested the desirability of analyzing the pellets for amount and kind of imperfection. The results of these analyses are summarized in Table 4.

Table 4 — Results of physical analyses of compression type pellets from southern Idaho seeding, 1947-1948

Sample No.	Weight in Grams of Material Analysed: 3/8" Pellets Whole	3/8" Pellets Partial[1]	1/4" Pellets Whole	1/4" Pellets Partial[1]	Usable Fragments[2]	Residue	Total Weight
1	980.1	217.3	438.8	37.4	42.0	11.4	1,727.0
2	616.7	78.2	453.6	17.0	34.3	511.4	1,711.2
3	916.9	473.0	147.4	50.7	80.0	30.3	1,698.3
4	—	39.6	909.1	364.4	200.4	97.1	1,610.6
5	197.3	628.2	206.2	219.5	251.7	200.1	1,703.0
6	442.8	358.6	210.1	153.3	461.0	76.7	1,702.5
Percentage for All Samples	31.1	17.7	23.1	8.3	10.6	9.2	100.0

[1] 1/4 pellet or larger.
[2] Less than 1/4 pellet.

It is apparent that the samples varied greatly in relative amounts of pellets of the two sizes and in the proportion of whole and imperfect pellets. This condition reflected the difficulties encountered in pellet processing on the Thorn Creek reseeding project, especially the effects of rerunning material which failed to form pellets the first time through the machine. Samples such as numbers 5 and 6 obviously could not be considered as normal and for this reason were excluded from further tests. These samples are of interest, however, in showing the effect of abrasive soil material and of subsequent excessive wheel wear in pelletizing by the Adams method.

Seed Damage and Germination

Pellet seed content, amount of seed damage and seed germination were studied in many samples. The technique employed for studying seed numbers and damage was to soak a sample (usually 25 pellets) in water and then examine the seed obtained when the pellets dissolved. In this way the numbers of mature seeds, both whole and broken, were determined, and the results reported on this basis.

The germination of both naked and pelletized seeds was tested by placing them on moistened filter paper in Petri dishes. Germination was tested also on the surface of soil in greenhouse flats. This latter procedure gave as uniform results for the seed pellets as did the Petri dish method, and appeared closer to field conditions. A large flat, subdivided by metal strips and watered by a simple overhead sprinkling device capable of delivering measured amounts of water, was used for these tests.

The size of sample used for the germination trials varied with the size and nature of the pellets, but in all cases enough material was used to provide a population of one hundred seeds or more. Two or more replicates of this size were used in each test.

The results of determinations of pellet seed content and seed breakage for crested wheatgrass are summarized in Table 5.

Table 5 — Seed content and percent breakage for various lots of pelletized crested wheatgrass

Pellet Type	Source	Number of seeds per pellet Whole	Broken	Total	Percent Broken Seed
Adams	Southern Idaho	6.8	4.8	11.6	41
Adams	Wyoming	6.9	3.0	9.9	30
Adams	Milk Ranch, Utah	5.2	2.3	7.5	31
Adams	Nevada	2.4	2.0	4.4	45
Adams	Skull Valley, Utah	2.3	1.7	4.0	43
Filtrol	Nevada	4.5	3.1	7.6	41
Vogelsang	Experimental Lots	1.2	0.1	1.3	8

The results of these tests show the high percentage of damage to crested wheatgrass seed resulting from pressure methods of pelletizing. The Adams type pellets differed considerably in respect to seed breakage. The amount of such damage in 3 lots, those from Idaho, Nevada, and Skull Valley, Utah, proved to be significantly higher (by the Chi-square test) than in the pellets from the Wyoming and Milk Ranch, Utah lots. No reason for this difference could be determined from examination of the pelletizing materials.

The type of Filtrol pellet used in the above tests was made by an extrusion process rather than this firm's usual coating method. The results in terms of seed breakage were similar to those obtained with the Adams process.

The amount of seed damage in pellets made by the coating process (Vogelsang) was low in all the samples studied.

Similar analysis of Adams type pellets from Arizona containing seed of other forage species gave comparable results. Seeds of bluebunch wheatgrass showed damage to the extent of 35 percent, while 42 percent of tall wheatgrass (**A. elongatum**) seeds were broken. Only in the case of Russian wildrye (**Elymus junceus**) was damage lower, being 24 percent.

From the tests noted above, together with others not reported, it was concluded that a considerable amount of seed breakage is inherent in the compression method of pelletizing seed. Seed breakage in pellets of this type has been reported by Allen ('48) and Stevenson ('49), but neither of these authors has reported detailed results. Bleak and Phillips ('50) found an average of 25 percent of injured seed in smooth brome and tall oatgrass pelletized by the Adams method. Other tests from the Intermountain Forest and Range Experiment Station, Ogden, Utah, indicate 42 percent breakage of crested wheatgrass seed in Adams type pellets.

Germination Tests

The results of germination tests in the laboratory and the greenhouse are presented in Table 6. The data indicate harmful effects

from the compression pelletizing methods on seed of all the species tested. Broken seed, which made up a third or more of the total in many samples, gave little or no germination. More striking than this was the low viability shown for many whole seeds, whether removed from the pellets or germinated within them. These seeds showed no visible injury, but failed to germinate, even under a variety of treatments.

The reduction in viability was marked in crested wheatgrass, although differences were found among lots from different sources. Similar results for crested wheatgrass have been reported by Allen ('48), Stevenson ('49) and Bleak and Phillips ('50). Allen obtained a germination rate of 14.7 percent for crested wheatgrass seed contained in Adams type pellets produced in Wyoming. These results check closely with those obtained by the present authors with material from the same source.

Table 6 — Laboratory and greenhouse germination of pelletized and unpelletized seed of range forage species

Kinds of Pellets and of Seeds			Germination in Percent			
			Pelletized			Unpelletized
			Laboratory		Greenhouse	
Pellet Type	Source	Forage Species	Whole	Broken	All Seed	Seed
Adams	Gooding, Idaho	Crested Wheatgrass	16.0	0	9.0	68
Adams	Wyoming	Crested Wheatgrass	—	—	13.0	*
Adams	Milk Ranch, Utah	Crested Wheatgrass	34.0	3.0	12.0	84
Adams	Skull Valley, Utah	Crested Wheatgrass	15.0	2.0	—	70
Filtrol	Nevada	Crested Wheatgrass	8.1	2.4	11.0	*
Vogelsang	Standard, 1948	Crested Wheatgrass	77.0	—	83.0	85
Adams	Gooding, Idaho	Yellow Sweetclover	—	—	38.0	78
Adams	Arizona	Tall Wheatgrass	30.0	10.0	16.0	*
Adams	Arizona	Bluebunch Wheatgrass	16.0	0	7.0	*
Adams	Arizona	Russian Wildrye	56.0	4.0	34.0	*

— Not tested.
* Not available for testing.

The viability of other species was affected also, although the degree of damage varied considerably. Tall wheatgrass and bluebunch wheatgrass reacted similarly to crested wheatgrass, while Russian wildrye and yellow sweetclover were affected much less. Bleak and Phillips ('50) found sweetclover to be less reduced in viability by compression pelletizing than were crested wheatgrass, smooth brome, timothy, orchard grass or tall oatgrass.

Pressure damage, secondary dormancy and death due to lack of aeration have been suggested as possible causes for this loss in viability of apparently sound seeds. No adequate physiological study of the problem appears to have been made. Whatever the cause, the phenomenon of reduced viability appears to be a feature of compression seed pellets. This physiological damage, combined with the large amount of mechanical injury render the compression pellets studied unsatisfactory as a method of preparing seed of range forage species for sowing.

DISCUSSION

With final results yet to come on many tests, full evaluation of all types of seed pellets cannot be made at this time. The data do show that the compression pellets failed to benefit their contained seed. Extensive mechanical injury to seed, plus a marked reduction in the viability of the remainder was found. In field tests, the pellets failed to aid in seedling establishment. These results are in agreement with those of others who have studied compression pellets, including Allen ('48), Stevenson ('49), Wagner and Kinkor ('49) and Bleak and Phillips ('50).

The situation with regard to coated pellets is not so clear. Preliminary tests have shown virtually no mechanical seed injury and only slight reduction in viability from this type of pellet. Studies have not progressed far enough to determine fully the effect of coated pellets on germination and seedling establishment in the field. In view of the general failure of large-scale range seedings of compression pellets, similar large plantings of the coated type would be unwarranted at present.

Since pelletized seed of range forage species is designed for surface sowing on lands not suitable for tillage, the results must be evaluated in comparison with broadcast naked seed. The two possible advantages of pelletized seed appear to lie in ease of aerial seeding, and in increased chances of obtaining satisfactory stands from broadcast seed.

The advantage in sowing is evident, for pelletized seed can be broadcast by airplane more accurately and uniformly than naked seed, and under weather conditions which render the use of naked seed impracticable. This advantage may be important in preventing critical delays in seeding.

While ease of seed distribution is of importance, it is a minor factor compared to that of obtaining increased stands. The results to date do not indicate any advantage for pelletized seed in this respect.

In view of the results obtained to date, the question arises as to how the pellets may be expected to aid their contained seed and what pellet qualities are required to perform this function. Since the physiology of seed pelletizing has been studied so little, it is difficult to know just what combination of characteristics would be most beneficial. From the studies made to date, the following qualities seem to be important.

First, the pellet should help to protect the contained seed from untimely germination followed by drying. In this respect, the pellet might serve in somewhat the same capacity as the soil covering obtained with tillage reseeding methods.

Second, the pellet should protect the seed from wind drift both during seeding and on the ground. Since most pelletizing materials are denser than naked seeds, this advantage is likely to be attained.

Third, the pelletizing process should take advantage of any op-

portunity to utilize seedling stimulants, fertilizers and disease inhibitors where these are shown to be of benefit. Rodent repellants would be desirable in some cases, but so far none has proved effective.

Fourth and most important of all, the pellet should persist in its desirable qualities for a long enough period to aid appreciably in seedling establishment. A pellet which disintegrates completely before germination is accomplished is likely to lose any beneficial qualities it may have possessed except for the mechanical aid in seeding.

In addition to the above qualities, it is obvious that the pelletizing process and materials must not injure the contained seed either mechanically or physiologically. This quality is a basic necessity, and one which has been lacking in the compression type pellets tested to date.

Even with satisfactory physical attributes, the advantage of pelletized seed would have to be established on an economic basis. Costs of the large-scale seedings made to date with compression pellets have been relatively low, but these data have little meaning because of the failure to establish satisfactory stands. The few seedings made with coated pellets have been more expensive, but these costs would no doubt be reduced if the method came into general use. With all pellet seedings, the weight of material to be flown is much in excess of that of the seed itself. The ratio of pellet materials to seed was found to vary from 33 to 1 in several lots of compression pellets to 8 to 1 in coated pellets.

Three major requisites, namely, satisfactory processing, success in seeding, and economic feasibility are involved in the question of pelletized seed for range use. Processing, although unsatisfactory in many cases to date, does not present an insuperable problem. The pellet attributes listed previously appear attainable, the most difficult task being that of determining the exact qualities desired. Success in seeding requires proof that broadcast pelletized seed is more effective in establishing stands than is unpelletized seed sown in the same manner. Results obtained to date have not shown any such advantage for seed pellets. Even if pelletized seed is shown to be more effective, there is still the question of costs to consider. As in any other range improvement measure, an economic advantage must exist if the practice is to become feasible.

Further large-scale plantings of pelletized range forage seed are not warranted at this time. The extent of the resources which would benefit from successful aerial planting of pelletized seed are such, however, as to justify further research. Some studies along this line are being continued by the University of Idaho.

ACKNOWLEDGEMENTS

Assistance rendered in this project by the departments of Agronomy and Agricultural Chemistry of the College of Agriculture, University of Idaho, is gratefully acknowledged. Thanks are due also to Lee A. Sharp, Instructor in Range Management, and James C. Moomaw, Research Fellow, Range Management, for help in the field and laboratory studies.

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